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Individual differences in nonlinguistic event categorization predict later motion verb comprehension

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ABSTRACT

This study probes how individual differences in early event perception predict later verb knowledge. At Time 1, when infants were 13 to 15 months of age, they saw videotaped silent scenes performed by a human actor. The goal was to see whether infants could form categories of *path* (a figure's trajectory with respect to a ground object) and *manner* (how an action is performed). Infants either saw the same manner (e.g., *jogging*) taking place across three different paths (*around, through*, and *behind*) or saw the same path (e.g., *around* a tent) taking place across three different manners (*running, crawling*, and *walking*). After familiarization, either the path or the manner was changed and visual fixation was monitored using preferential looking. At Time 2, the same children were tested on their *comprehension of verbs* in a two-choice pointing task showing two simultaneous actions (e.g., running vs. jumping). Success at categorization of path and manner at Time 1 predicted verb comprehension at Time 2, even when taking language knowledge at both time points into account. These preliminary results represent headway in identifying the factors that may contribute to children's language learning. They suggest that skill in categorizing semantic components present in nonlinguistic events is predictive of children's later verb vocabulary.

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Introduction

The power that language affords for expression would be lost if we could name only objects such as *ball* and *table.* Relational terms such as verbs and prepositions allow us to describe relations between entities (e.g., the ball is *under* the table, the cat is *chasing* the mouse). Relational term learning involves three steps (Golinkoff et al., 2002; Golinkoff & Hirsh-Pasek, 2008; Pulverman, Hirsh-Pasek, Golinkoff, Pruden, & Salkind, 2006). First, infants must parse and discriminate between event components. For example, the action of *playing on the playground* can be divided into smaller units such as *running to a slide, climbing the ladder, sliding down* and *skipping around the slide,* and *going up the ladder* again. Second, children must categorize these event components when they are seen in varying contexts. That is, children must recognize that "sliding" is "sliding" regardless of a change in figure or ground (e.g., the *girl* [the figure] is sliding down the *slide* [the ground object] vs. the *boy* is sliding down the *stairs*). Third, children must learn how their language encodes these components of events (e.g., Golinkoff et al., 2002; Golinkoff & Hirsh-Pasek, 2008). English, for example, typically encodes how an action is performed (the *manner*) within the main verb, placing the path of the action (e.g., *around* the slide) into a satellite prepositional phrase (Talmy, 2000). Spanish, on the other hand, emphasizes the *path* of the action (i.e., the movement of the figure with respect to a ground object) in verbs, placing the manner of motion into optional gerunds (as in "*Una mujer* <u>*sale*</u> *de la casa corriendo*": "A woman <u>exits</u> the house [running]"). Thus, learning verbs requires parsing and categorizing action sequences and mapping labels to these event components (Maguire, Hirsh-Pasek, & Golinkoff, 2006). The current study focused on the relationship between the second and third steps: the categorization of the event components of path and manner and later verb knowledge.

Infants' processing of event components

Combining linguistic theory and event processing, research has begun to examine the conceptual precursors to relational terms during infancy (e.g., Casasola & Cohen, 2002; Choi & Bowerman, 1991; Choi & Hattrup, 2012; Golinkoff & Hirsh-Pasek, 2008; Lakusta, Wagner, O'Hearn, & Landau, 2007; Mandler, 2004; Pulverman, Golinkoff, Hirsh-Pasek, & Sootsman Buresh, 2008; Pulverman, Song, Hirsh-Pasek, Pruden, & Golinkoff, 2013). Pulverman and colleagues (2008, 2013), for example, demonstrated that 7-month-old English-learning infants attend to path and manner changes in nonlinguistic dynamic events. Using a habituation paradigm, infants were habituated to an animated starfish performing both a path and a manner (e.g., *spinning under* the ball). At test, infants dishabituated to both a path change (e.g., spinning *over* the ball) and a manner change (e.g., *jumping jacks* under the ball), suggesting that they had discriminated between different instances of these two event components.

However, discrimination of path and manner is not sufficient for event processing; children need to form a *category* of these event components. Recent work suggests that infants can in fact categorize paths and manners by 13 months of age. In one study (Pruden, Roseberry, Göksun, Hirsh-Pasek, & Golinkoff, 2013), infants were familiarized to an animated starfish traveling on the same path (e.g., *under* a ball) performed with three different manners (e.g., *spinning, twisting,* and *toe-touching*). At test, they were presented with the starfish traveling on the same path in a new manner (e.g., *jumping jacks under* the ball) versus the starfish traveling on a new path in a new manner (e.g., *jumping jacks over* the ball). If infants can form a category of the path *under,* they should recognize *over* as being a new path despite the change in manner in both displays. Infants succeeded at this task by 10 months of age, and by 13 months they succeeded in an analogous task for the categorization of manner (Pruden, Göksun, Roseberry, Hirsh-Pasek, & Golinkoff, 2012). Additional evidence suggests that 10- to 12-month-old infants form nonlinguistic categories of manners (e.g., *hopping* and *marching*) over five different actors and across changing paths (Song, Golinkoff, Ma, Seston, & Hirsh-Pasek, 2008). Indeed, infants appear to prefer to process events categorically rather than focus on metrical changes (Roseberry, Goksun, Hirsh-Pasek, & Golinkoff, 2012). Together, these studies demonstrate that infants can categorize path and manner, both of which might be building blocks of relational terms.

How children map verbs to events

Although infants show evidence of conceptualizing events, verbs in particular are known to be difficult to learn (Gentner & Boroditsky, 2001; Bornstein et al., 2004). Challenges in verb learning may lie in the mapping of words onto actions. Indeed, Imai and colleagues (2008) found that English-reared children have trouble in learning and extending a novel verb even well into the fourth year of life. Although 3-year-old children who heard a sentence with a novel word corresponding to a noun (e.g., "Look! This is a *blick*") correctly chose the novel object as the label's referent, 3-year-olds who heard a novel verb (e.g., "Look! She's *blicking*") could not reliably choose the correct referent (i.e., the action) until 5 years of age. What are the factors that influence children's ability to map words onto events? A hybrid theory of language development, the emergentist coalition model (ECM), may help to unpack the complexity of verb learning (Hollich et al., 2000; Katerelos, Poulin-Dubois, & Oshima-Takane, 2011). The ECM suggests that children have access to a number of co-occurring cues for word learning but home in on those cues at different developmental time points. At first, infants map words to the referent that is most interesting or salient. Only later do they use the speaker's social intent coupled with linguistic cues to zero in on word reference.

Infants appear to map novel verbs onto the action or event that "stands out" from their perspective. Brandone, Pence, Golinkoff, and Hirsh-Pasek (2007) explored the extent to which children rely on perceptual salience as a cue in verb learning by teaching the name for either an interesting action with a result or a boring action without a result. At 21 months of age, children learned the name of the action with a result (i.e., pressing a Morse code key produced a tone) but not the label for that same action when the result was disabled. It was not until 33 months that children learned the name of the action without a result. Children more readily form mappings between perceptually salient actions and words than between verbs and uninteresting actions.

Even if an event that a verb labels is perceptually salient, mapping a verb to an action is still not an easy task; ambiguity exists as to which component in a scene a verb refers. Social information can help; caregivers can scaffold children's verb learning by using nonlinguistic cues to signal verb meaning. In fact, Roseberry, Hirsh-Pasek, and Golinkoff (2014) investigated whether social contingency would support verb learning among 24- to 30-month-olds. Children were shown novel actions and taught novel verbs in one of three conditions: live interaction training, socially contingent training over video chat, and noncontingent video training. Children learned novel verbs only in live interactions and video chats, both of which contained socially contingent interactions. Infants may use social cues such as the experimenter's eye gaze to direct their attention to the action named by the novel verb.

Although perceptual and social cues can play a role in verb learning, extralinguistic context can also be insufficient for interpreting verb meaning. For example, abstract verbs such as *think* and *believe* are difficult to understand with perceptual and social cues alone. In addition, the same scene can be described by using different verbs (e.g., the dog *chases* the cat vs. the cat *flees from* the dog). Syntactic bootstrapping theory suggests that children exploit the number and arrangement of noun phrases in the sentence to compute verb meaning and the speaker's perspective on an event (Gleitman, 1990). Fisher, Gleitman, and Gleitman (1991) showed that there is a one-to-one correspondence between participants in an event and the number of noun phrases in a clause. Thus, an intransitive verb such as *laugh* or *sleep* has one noun phrase argument that corresponds to an event with a single participant; a transitive verb such as *hit* or *push* has two noun phrase arguments and describes events with two participants. By 19 months of age, infants appear to expect a correspondence between event participants and argument number (Brandone, Addy, Pulverman, Golinkoff, & Hirsh-Pasek, 2006). Other research suggests that children as young as 22 months are indeed capable of using the number of arguments and their arrangement to learn whether a verb is transitive or intransitive even in the face of complex events (e.g., Fisher, 1996; Gleitman, 1990; Hirsh-Pasek & Golinkoff, 1996; Naigles, 1990).

The literature on verb learning has primarily focused on mapping words onto events and less on the role of infants' ability to conceptualize components of dynamic events (Casasola & Cohen, 2002; Göksun et al., 2011; Pruden et al., 2012; Pulverman et al., 2013). Comprehending and producing relational terms requires that infants have the conceptual knowledge necessary to make sense of events and actions. In particular, categorization of event components entails grouping together similar events performed by different agents and locations and with variations in manner such as different speeds (Pruden et al., 2012). Furthermore, infants must categorize event components that are labeled in their native language. For example, English-speaking children must recognize that, regardless of changes in other extraneous variables (e.g., different locations), the action of jumping receives the label "jumping." English tends to have more manner verbs than path verbs, whereas languages like Spanish are more likely to encode path in the main verb (Talmy, 2000). Thus, researchers claim that to learn verbs infants must become aware of how their native language tends to encode events (Gentner & Boroditsky, 2001; Golinkoff et al., 2002; Golinkoff & Hirsh-Pasek, 2008).

Yet, to make the case that infants' sensitivity to event components is a prerequisite to relational term learning, it is critical to longitudinally establish the link between infants' ability to categorize event components and their later knowledge of verbs. Past studies have assessed when infants discriminate and categorize event components such as path, manner, and ground (i.e., stationary setting) using cross-sectional designs (Göksun et al., 2011; Pruden et al., 2012; Pulverman et al., 2013). Other cross-sectional studies have shown that infants' perception of event components is related to vocabulary level in their native language (Göksun, Hirsh-Pasek, & Golinkoff, 2010). A longitudinal design is key to determining whether individual differences in event component processing during infancy predict later relational vocabulary.

Analogously, in the phonological domain, individual differences in infants' discrimination between two phonetic contrasts (/ta/ vs. /pa/) at 6 months of age predict language outcomes at 13, 16, and 24 months as measured by the MacArthur–Bates Communication Development Inventory (MCDI; Kuhl, Conboy, Padden, Nelson, & Pruitt, 2005). Similarly, Tsao, Liu, and Kuhl (2004) found that infants' speech perception skills at 6 months of age significantly predicted word understanding, word production, and phrase understanding at 13, 16, and 24 months. Other speech and lexical processing abilities, such as speech segmentation and word recognition, have also been shown to predict later language outcomes. Newman, Ratner, Jusczyk, Jusczyk, and Dow (2006) found that 12-month-olds' performance on a speech segmentation task was related to their expressive vocabulary (as measured by the Test of Language Development) at 24 months. In addition, Fernald and Marchman (2012) showed that 18-month-olds' ability to rapidly identify familiar spoken words predicted their vocabulary growth a year later. Lexical processing speed at 18 months of age was the strongest predictor of receptive vocabulary at 36 months as measured by the Peabody Picture Vocabulary Test (PPVT; Marchman, Adams, Loi, Fernald, & Feldman, in press). An open question is whether a similar pattern may be true for the semantic domain. Do individual differences in infants' skill in categorizing nonlinguistic event components have consequences for their later relational vocabulary acquisition?

The current study

This study is the first to investigate whether individual differences in infants' ability to categorize manner and path predict their later knowledge of verbs. To assess this question, 13- to 15-month-old infants participated in a nonlinguistic path and manner categorization task (Time 1) and were tested on their verb knowledge at 27 to 33 months (Time 2). Verb knowledge at Time 2 was measured via a verb comprehension tool based on a modification of the intermodal preferential looking paradigm (Golinkoff, Ma, Song, & Hirsh-Pasek, 2013; Hirsh-Pasek & Golinkoff, 1996). Existing vocabulary assessments, such as the PPVT, tend to be noun biased and underestimate children's verb knowledge (Tardif, Gelman, & Xu, 1999). In addition, the PPVT consists of static images, implicitly assuming that children recognize motion events in static drawings, an assumption questioned by research (Cocking & McHale, 1981; Pavlova, Krageloh-Mann, Sokolov, & Birbaumer, 2001). To overcome the limitations of current vocabulary assessments, we created a verb comprehension task. If the nonlinguistic categorization of path and manner is a fundamental step in the process of verb learning, we expected a correlation between infants' preference for one event at test at Time 1 and the proportion of verbs children correctly identify at Time 2 even when controlling for children's language knowledge at both time points.

Method

Time 1: Infants' categorization of path and manner of motion

Participants

A total of 25 13- to 15-month-old full-term, monolingual, English-reared children from middle-class households in two suburban northeastern U.S. cities formed the final sample. Six (24%) participants were excluded from the sample due to fussiness. Half of the infants were randomly assigned to the *manner* condition (nine girls; mean age = 14.3 months, *SD* = 1.8) and half to the *path* condition (six girls; mean age = 14.1 months, *SD* = 0.71). Parents completed the short form of the MacArthur–Bates Communication Development Inventory, Toddler Level I (MCDI-I; Fenson et al., 1994). Infants' overall receptive vocabulary as measured by the MCDI-I ranged from 1 to 48 words (*M* = 20.68, *SD* = 13.27). Infants comprehended a mean of 17 of 44 nouns (38%) and 4 of 14 verbs (28%). The MCDI samples much fewer verbs than nouns.

Stimuli

The stimuli were a series of realistic video clips depicting a female actor performing events in the presence of a ground object (a yellow tent-like structure) in a white room (Fig. 1). The four manners used were *hopping, jogging, spinning*, and *crawling*. The four paths used were *around* (the actor started in the front center and made a full circle around the tent), *through* (the actor started in the back right corner, went through the tent on a diagonal trajectory toward the front left corner, then reversed her

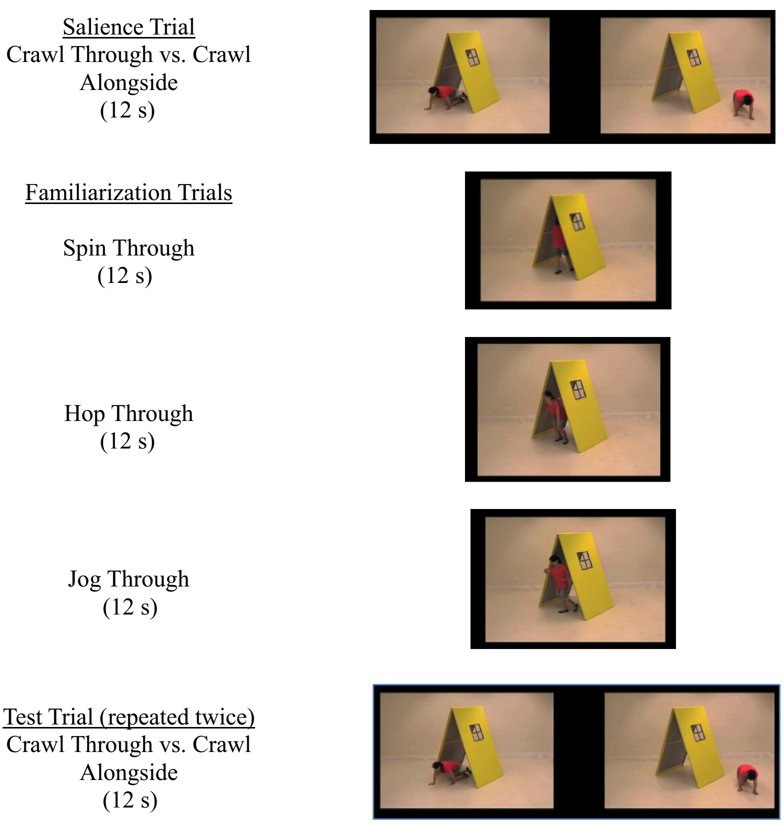

Fig. 1. Stimuli presented to the infants in the path categorization condition.

path to return to the back right), *in front of* (the actor started on the left and made a semicircle in front of the tent to the right side, then reversed her path and returned to the left side), and *alongside* (the actor started in the back right corner and made a straight path to the front right corner, turned around, and reversed her path to the back right corner). All path trajectories took the same amount of time to complete (see Konishi, Pruden, Golinkoff, & Hirsh-Pasek, 2016).

Design and procedure

The study employed the preferential looking paradigm, and all stimuli were presented in silence (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Hirsh-Pasek & Golinkoff, 1996). Infants were seated on their parent's lap 45 inches from a 35-inch television screen. Parents were instructed to close their eyes and refrain from talking to their children. All parents complied with these instructions. A camera, hidden behind a small hole in a black curtain underneath the television, recorded infants' eye movements to the events shown. The design and procedure were identical across path and manner conditions. Two between-participants conditions were created for the manner condition (*jog* and *hop*), and two between-participants conditions were created for the path condition (*through* and *around*). Each path and manner condition tested a unique manner or path category. We used a range of event components that prior research suggested were distinct from one another for young children (Casasola, Cohen, & Chiarello, 2003; Pruden et al., 2013; Song et al., 2008).

Infants viewed three types of trials in the following fixed order: (a) a *salience trial,* (b) three *familiarization trials*, and (c) two *test trials.* Each trial was separated by a 2-s interval during which infants saw and heard a laughing baby that was centered on the screen. The baby served to reorient infants' attention to the center of the screen before the next trial began.

Salience trial. Infants viewed a single 12-s salience trial in which both of the stimuli to be presented in the test trials were displayed simultaneously on a split-screen (e.g., *spin through* and *hop through* for the manner condition, *crawl through* and *crawl alongside* for the path condition) (Fig. 1). The salience trial assessed infants' a priori preferences for what would become the test events.

Familiarization trials. Three 12-s familiarization trials followed the salience trial for a total of 36 s of familiarization. Fixed length familiarization trials ensured that all participants had an opportunity to view the events for the same amount of time.

Manner condition. Each of the familiarization trials displayed the actor performing a single manner across three different paths that varied across conditions. For example, half of the infants participated in the "jog" condition and saw an actor *jog through* the tent during the first familiarization trial, *jog in front of* the tent during the second familiarization trial, and *jog around* the tent during the third familiarization trial (Fig. 1). The other half participated in the "hop" condition and saw an actor *hop alongside* the tent first, *hop around* the tent second, and *hop in front of* the tent during the third familiarization trial.

Path condition. Each of the familiarization trials displayed the actor performing three different manners across a single path. However, the varying manner differed across conditions. For example, infants who participated in the "through" condition saw an actor *hop through* the tent during the first familiarization trial, *spin through* the tent during the second familiarization trial, and *jog through* the tent during the third familiarization trial (Fig. 1). Infants who participated in the "around" condition saw an actor *spin around* the tent first, *crawl around* the tent second, and *hop around* the tent during the third familiarization trial.

Test trials. Two 12-s test trials, identical to those infants had seen during the salience trial, followed the familiarization trials.

Manner condition. To assess whether infants had detected a change in the manner of motion (e.g., *jog*) across multiple exemplars of path, infants simultaneously viewed on the split-screen (a) a *novel within-category* test event in which the familiar manner was performed along a novel path (e.g., *jog alongside*) and (b) a *novel out-of-category* test event in which a novel manner was performed along a novel path (e.g., *hop alongside*). Importantly, both test events contained a novel component (e.g., *alongside*), whereas only one event contained both a novel path (e.g., *alongside*) *and* a novel manner (e.g., *hop*). The inclusion of the same novel component (e.g., *alongside*) in both split-screen events avoided the possibility that children perceived path and manner as a single unit. This stringent test ensured that infants extracted the critical event component (manner) above and beyond a change in path. As demonstrated in prior studies, if infants successfully formed a category of the figure's manner of motion, they should show a significant preference for the novel out-of-category test event in which both event components were new (e.g., *hop alongside*).

Path condition. To assess whether infants had detected a change in the path of motion (e.g., *through*) across multiple exemplars of manner, infants simultaneously viewed on the split-screen (a) a novel within-category test event in which a novel manner was performed along the familiar path (e.g., *crawl through*) and (b) a novel out-of-category test event in which a novel manner was performed along a novel path (e.g., *crawl alongside*). As in the manner condition, both test events contained a novel component; only one test event contained both a novel path and a novel manner. If infants successfully formed a category of the figure's path of motion, they should show a significant preference for the novel out-of-category test event in which both event components were novel (e.g., *crawl alongside*). For all split-screen trials, the side on which the *novel test event* was presented was counterbalanced.

Coding reliability and dependent variable

Research assistants who were blind to infants' condition coded infants' visual fixation to each event offline, frame by frame, by pressing a button to indicate how long infants looked to the left, right, and center of the screen. Infants' novelty preference scores were calculated for each infant by taking their looking time toward the novel out-of-category event and dividing it by their total looking time to both events. A proportion above .50 meant that infants looked longer at the novel out-of-category event than at the within-category event; a proportion below .50 meant that they watched the within-category event longer. Studies have found proportion of looking to the novel stimulus to be a sensitive measure of infants' categorization skills (Quinn, Eimas, & Rosenkrantz, 1993). Novelty preference scores were averaged across the two test trials (12 s per trial) and calculated for each participant. To calculate intercoder reliability, two trained coders independently coded 20% of participants. Reliability across both experiments was high ($r > .98$).

Time 2: Assessment of children's verb knowledge

Participants

The participants were a subset of infants who participated in a study (Konishi et al., 2016) that explored the Time 1 data except with a larger sample size ($N = 60$). Although we invited all infants who were in the Time 1 categorization study to participate in the verb comprehension study at Time 2, a total of 25 children completed the verb comprehension task (15 girls; mean age = 30.14 months, $SD = 4.60$) at 27 to 33 months of age. Because it was difficult to locate some of the children who participated in the first study, a wide age range resulted, causing children to come back to the lab at different times relative to their Time 1 visit. In addition, 10 children (40%) were not included in the final sample at Time 2 due to side biases ($n = 2$) or fussiness ($n = 8$). The average time span between Time 1 and Time 2 was 16.08 months ($SD = 2.5$), and the variance of the average time span was 8.27 months. The average time span between Time 1 and Time 2 had no significant effect on the proportion of correctly identified verbs at Time 2 ($r = .28$, $p = .16$).

At Time 2, overall vocabulary knowledge was also evaluated through the short form of the MCDI-II (Fenson et al., 1994). Productive vocabulary ranged from 12 to 100 words ($M = 76.84$, $SD = 23.06$), with children producing a mean of 66 of 89 nouns (74%) and 9 of 15 verbs (60%).

Verb comprehension task

The verb comprehension task presented children with a split-screen depicting two different, side-by-side actions performed by the same human actor, while the experimenter prompted children to point to the target action (e.g., "Where is she *eating* the cake?") (see Golinkoff et al., 2013, for details). Although the same actor performed the actions that were paired with each other, seven female actors appeared in the task to keep children engaged. The verbal prompt was given once but could be repeated once if necessary for each trial. We repeated the prompt on every trial for more than half of the children who participated. The experimenter changed the slide as soon as the participants responded to the verbal prompt by pointing to one of the actions. The test took approximately 10 to 15 min to administer. Children saw two types of trials: warm-up and test trials.

Warm-up trials. Children saw two different familiar objects (i.e., a tiger and a cupcake) side by side on a computer screen and were asked to identify the target object (e.g., "Where is the *cupcake*?"). The three warm-up trials consisted of familiar nouns and their referents and were designed to familiarize children with seeing two images simultaneously, listening to a prompt, and then pointing to one of the two images. All children pointed to the correct item on all three trials.

Test trials. The test trials included 18 verb pairs presented across 36 trials, with 29 transitive verb pairs that were depicted using the same object (e.g., *squeezing* a balloon vs. *blowing* a balloon) and seven intransitive verb pairs (e.g., *running* vs. *jumping*) (see Table 1). Each trial lasted 12 s. Critically, the verbs were represented using dynamic motion.

Verbs that were easy to represent on video were chosen primarily from the MCDI and a study conducted by Masterson, Druks, and Galliene (2008). The MCDI verbs selected were normatively produced by at least 50% of children learning American English by 30 months of age (Fenson et al., 1994). Masterson and colleagues' (2008) study identified a list of verbs that children comprehend between 3 and 5 years of age.

Children were randomly assigned to one of two conditions that differed by trial order. Children were tested on each verb once, although they saw each verb pair twice. The first 18 trials prompted children to point to one action in each pair; the second 18 trials were repeated in the same order and asked children to point to the other action in each pair. For example, on Trial 1 children might be asked to point to *squeezing*, and on trial 19 they might be asked to point to *kicking*. The experimenter always used the same syntax for transitive verbs and always named the referent (e.g., "Where is she *throwing* the balloon?" vs. "Where is she *kicking* the balloon?") (Table 1).

Table 1
The 18 verb pairs organized by whether they were intransitive or transitive.

Intransitive pair		
Run	Jump	
Stretch	Clap	
March	Spin	
Dance	Cry	
Transitive pair		*Direct object*
Feed	Hug	Cookie Monster
Pour	Drink	Juice
Shake	Open	Gift
Read	Rip	Newspaper
Roll	Bounce	Basketball
Lift	Pull	Pooh bear
Drop	Bite	Ice Cream
Kiss	Tickle	Teddy bear
Squeeze	Blow	Balloon
Kick	Throw	Balloon
Lick	Break	Lollipop
Wash	Rock	Baby
Cut	Tie	Ribbon
Eat	Push	Cake

Note. During test, verbs were interspersed and order was counterbalanced.

Coding and dependent variable

A response was considered correct when children clearly pointed to one side of the screen or when they touched one of the images. Incorrect responses included pointing at the nontarget, pointing at both alternatives after being explicitly prompted to point to one, and failing to respond even after two prompts. The dependent variable was the number of verbs children correctly identified divided by the total number of verbs. A secondary coder independently coded the responses. Any discrepancies were discussed after the experiment, and a single set of responses were agreed on for scoring. Discrepancies consisted of one of the coders missing a child's response, although this happened very infrequently.

Results

Variability in children's performance at Time 1 and Time 2

Infants' novelty preference scores at Time 1 ranged from .27 to .92 ($M = .52$, $SD = .14$) (Table 2). Although infants' mean novelty preference scores were at chance overall, we examined how *individual differences* in infants' categorization of events related to their later knowledge of verbs. In contrast, Konishi and colleagues (2016) explored the Time 1 data of the current study except with a larger sample size ($N = 60$), of which our Time 1 data were a subset. Konishi and colleagues found that infants' novelty preference scores were significantly above chance. Thus, infants' novelty preference scores in the current study were likely at chance due to a small sample size, not due to an inability to categorize these event components.

In the current study, infants' novelty preference scores did not differ by condition (path or manner), indicating that they performed equivalently in the path and manner conditions, $t(23) = 0.28$, $p > .05$. In addition, a one-way between-participants analysis of variance (ANOVA) assessed whether infants' novelty preference varied depending on the event component (i.e., *jog, hop, around, through*) on which infants were tested. Results found no interaction between infants' novelty preference and the event components to which they were familiarized, suggesting that infants showed approximately equal sensitivity to all of the event components tested, $F(3, 21) = 1$, $p > .05$.

There was also considerable variability in children's performance on the verb task at Time 2. Children's performance on the verb task ranged from .27 to 1 ($M = .80$, $SD = .18$) (Table 2) and was significantly above chance, $t(24) = 8.4$, $p < .05$.

Does infants' ability to categorize path and manner predict later verb knowledge?

Infants' novelty preference scores across *both* the path and manner conditions significantly correlated with their verb vocabulary a year later ($r = .44$, $p = .01$), as can be seen in the scatterplot shown in Fig. 2. That is, those who had a greater novelty preference score at 13 to 15 months of age also knew more verbs at 27 to 33 months. Furthermore, we found a significant correlation between infants' novelty scores at Time 1 and verb their task performance at Time 2 even when we

Table 2
Descriptive statistics.

Measure	*M*	*SD*	Min	Max
13–15 months				
Overall MCDI score[a]	20.68	13.27	1	48
Novelty preference score[b]	.52	.14	.27	.92
27–33 months				
Overall MCDI score	76.84	23.06	12	100
Verb comprehension task performance[c]	.80	.18	.27	1.00

[a] Number of words reported on the short-form of the MacArthur–Bates Communication Development Inventory (MCDI).
[b] Proportion of looking to the novel event at test.
[c] Proportion of correctly identified verbs on the verb comprehension task.

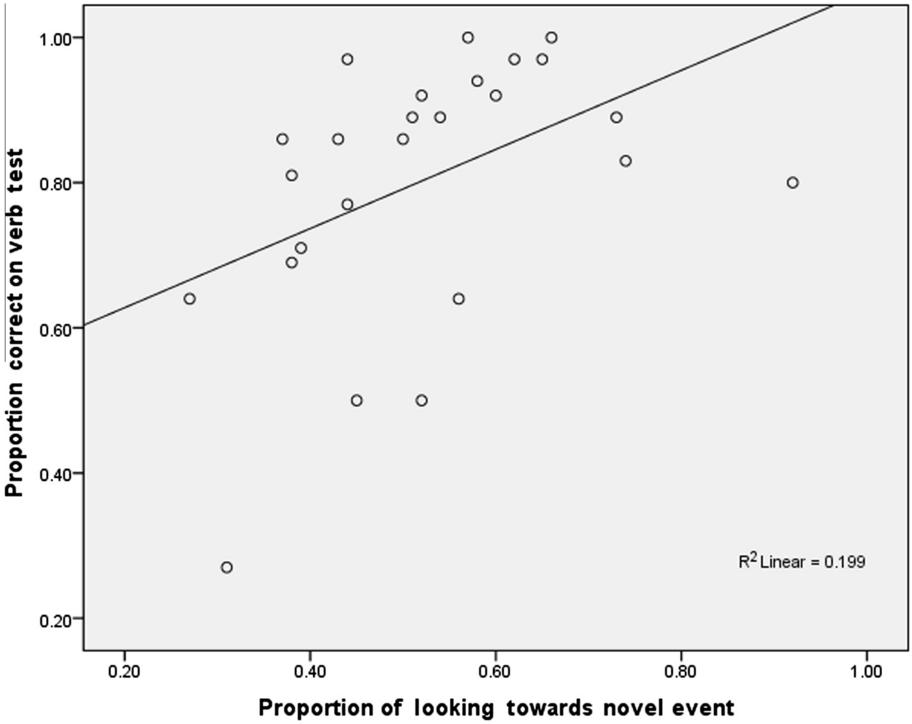

Fig. 2. Scatterplot representing the link between infants' proportion of looking to the novel event and percentage of correctly identified verbs.

gave children credit only when they answered both verbs in a pair correctly ($r = .39$, $p = .05$), a very conservative scoring scheme. Given the small sample size, we did not find a significant relationship between infants' ability to categorize event components and their later verb knowledge when we split infants by condition (path or manner).

Time 1 categorization ability predicts Time 2 verb comprehension task performance even when controlling for overall vocabulary

One possibility is that the link between infants' categorization skills and their later verb knowledge is driven by their overall vocabulary knowledge (as measured by the MCDI) at Time 1. That is, infants' vocabulary knowledge at 13 to 15 months of age may be responsible for the correlation between categorization skills and later verb knowledge. To address this question, we conducted a regression analysis in which we included children's overall MCDI scores at Time 1, MCDI scores excluding verbs at Time 1, and infants' event categorization skill as measured by their novelty preference score from Time 1 as predictors of later knowledge of verbs at Time 2. The regression analysis predicting children's verb task performance was significant ($R^2 = .20$), $F(2, 24) = 2.8$, $p < .05$. Infants' novelty preference scores at Time 1 was a significant predictor variable, but vocabulary at Time 1 was not. These results suggest that infants' ability to categorize path and manner predicts children's Time 2 verb knowledge above and beyond their vocabulary skills at Time 1 ($\beta = .47$, $p < .05$) (Table 3).

Time 1 categorization ability predicts Time 2 verb knowledge as measured by the MCDI

We found that infants' categorization skills predict their later verb knowledge as measured by the verb comprehension task. An open question is whether infants' novelty preference scores also predict children's verb comprehension as measured by the MCDI at Time 2. To conduct this analysis, we used

Table 3
Summary of regression analyses.

Predictor	Model 1: Verb comprehension performance				Model 2: Verb comprehension performance			
	B	*SE* (*B*)	*β*	*sr*^{2}	*B*	*SE* (*B*)	*β*	*sr*^{2}
Overall MCDI	−.01	.01	−1.24	−.31				
MCDI without verbs	.01	.01	1.16	.31				
Novelty preference	.81	.27	.66*	.53*	.49	.22	.40*	.39*
Age at Time 2					.009	.007	.23	.23
R^2	.20*				.18*			

* $p \leqslant .05$.

only the verbs on the MCDI and excluded all other words. There is a positive correlation between infants' novelty preference at Time 1 and parental report of verb knowledge at Time 2 ($r = .58$, $p < .05$). These findings suggest that infants' novelty preference scores predict children's verb knowledge not only as assessed by the verb task but also as assessed via the MCDI. However, another possibility is that infants' categorization of event components relates to children's overall language knowledge and does not uniquely predict verb knowledge. Perhaps not surprisingly, vocabulary scores on the MCDI at Time 1 correlated significantly with vocabulary size at Time 2 ($r = .38$, $p < .05$). We correlated infants' novelty preference scores with their Time 2 MCDI vocabulary removing the verbs on the MCDI. Results showed no significant correlation between infants' novelty preference scores and Time 2 MCDI scores without the verbs included ($r = .34$, $p > .05$). These results suggest that there may be a unique relationship between infants' categorization of event components and later verb vocabulary.

Age at Time 2 does not predict verb comprehension performance

Because children's age at Time 2 ranged from 27 to 33 months, we included age at Time 2 as a variable in a regression model. This model included infants' path and manner categorization skills at Time 1 and age at Time 2 as predictor variables and included verb knowledge at Time 2 as the outcome measure. The regression model was significant ($R^2 = .18$), $F(2,24) = 3.72$, $p = .04$, but only infants' ability to categorize path and manner at Time 1 significantly predicted children's verb vocabulary at Time 2 ($\beta = .40$, $p = .04$).

The verb test is validated against parental report

Finally, we examined whether there was a correlation between parental report of verb knowledge at Time 2 and performance on the verb task at Time 2. Parental report of verb knowledge at Time 2 (MCDI) correlated with verb task scores at Time 2 ($r = .42$, $p < .05$), suggesting that the verb task is valid. Children who identified many verbs on the verb task were also reported to have a large verb vocabulary by parents at the same point in time.

Together, these results suggest that infants' ability to categorize path and manner is predictive of their later verb knowledge as measured by the verb comprehension task as well as the MCDI. There appears to be a unique link between categorization of path and manner and later verb knowledge given that there is no significant relationship between event categorization and later overall MCDI scores with the verbs removed. Thus, the relationship between event categorization and later verb knowledge does not appear to be driven by children's overall vocabulary knowledge or their age.

Discussion

To acquire the verbs and prepositions of their language, infants must process the semantic components that their language encodes. The ability to form categories of these semantic components (e.g., paths, manners) has been hypothesized to be an essential component of mapping language onto events (Golinkoff & Hirsh-Pasek, 2008). Indeed, previous research suggests that infants notice changes in paths and manners by 7 months of age (Pulverman et al., 2008, 2013) and form categories of path and manner by 10 to 14 months (Pruden et al., 2012, 2013). Despite the theoretical significance of examining the long-term effects of perceiving events, no previous studies have assessed infants' ability to form categories of event components and their later knowledge of verbs.

To address this gap, the current study examined whether individual differences in 13- to 15-month-old infants' ability to categorize path and manner in nonlinguistic dynamic events predicted their understanding of verbs a year later. To investigate this question, we included infants' novelty preference scores at 13 to 15 months, infants' overall vocabulary knowledge, and vocabulary knowledge excluding verbs at 13 to 15 months (MCDI) in a regression model. These findings suggest that infants' ability to categorize path and manner at 13 to 15 months predicts verb vocabulary at 27 to 33 months above and beyond their vocabulary knowledge at Time 1. Similarly, infants' ability to form categories of path and manner predicted children's later verb knowledge as measured by the MCDI-II. In the next regression model, we included infants' event categorization skills and age at Time 2. Results showed that infants' ability to categorize path and manner was the only significant factor in the model, suggesting that there is a relationship between infants' early event categorization skills and their later knowledge of verbs even when considering the fact that children's age varied at the Time 2 verb comprehension test.

Intriguingly, there appears to be a unique link between event categorization and later verb knowledge given that there was no significant correlation between infants' ability to categorize event components and their overall vocabulary at Time 2. There are, however, some caveats to take into consideration. First, due to a small sample size, we combined the children from an earlier between-participants design to consider how infants' path *and* manner categorization skills relate to their later knowledge of verbs. Second, although an ideal study would prospectively track infants who participated in event processing studies into early childhood to examine possible links to later verb vocabulary, a reasonable first step was taken here by examining this issue retrospectively.

Why might there be a relationship between infants' ability to categorize path and manner in nonlinguistic events and their later knowledge of verbs? This novel finding opens a number of possible explanations, all of which need to be pursued in further research. One possibility is that perhaps children who are adept at forming manner and path categories are skilled in extracting event invariants in general. Although English tends to have an abundance of manner verbs, it also has path verbs (e.g., descend, ascend). Some researchers argue that path of motion is one of the core components of a motion event and is fundamental to the acquisition of verbs in general (Mandler, 2004). Thus, the ability to categorize both path *and* manner, and perhaps other event components (e.g., ground), may be important for children's later knowledge of verbs. Children need not remember all aspects of the event, just components that appear consistently. Noticing similarities in the way actions are performed, and perhaps focusing on their outcomes, while at the same time abstracting core meaning even from differences in the figure or which ground object is involved may be important for infants' ability to learn novel verbs. In the case of the current study, the ability to extract the common path or manner regardless of changes in other aspects of the event is key. If children can retain the critical elements of the events they witnessed, perhaps this would explain why they spend more time looking at the novel events at test. More efficient storage of event components in memory predicts that these children may remember the "verbal essence" (Golinkoff et al., 2002) or overall shape of actions labeled by verbs in the language they hear. This possibility leads to an empirical prediction, namely that children who are better at detecting novel event components relative to their peers should learn *new* verbs more readily. That is, even if the new verbs are used to label variations in the action or the elements involved, these children should excel in novel verb *learning*.

A second possibility is that skill in extracting the components of events that are most often encoded in the verbs of one's language offers children an advantage. On witnessing a new action and hearing a novel verb, children might be more likely to zero in on the particular event component that the novel verb is naming. Languages differ in how they encode properties of events in their verbs (Talmy, 2000). English typically encodes a figure's manner of motion in the main verb, whereas Spanish tends to encode path information in verbs. Although these typological differences between languages in the expression of motion is probabilistic, the ability to conceptualize motion events in a way that is consistent with one's native language ("thinking for speaking"; Slobin, 1996) may boost children's ability to map labels onto that conceptual knowledge. The current study focused on English-reared infants' ability to form categories of path *and* manner. Although English is a manner-biased language, English also has path verbs. Perhaps the ability to categorize both types of event components is important for later verb learning. In contrast, when children focus on components that are *not* highlighted in their language, their early learning of verbs may suffer. Choi (2006) found that English-reared children with a smaller vocabulary and those who had not produced the preposition "in" were more likely to show sensitivity to the Korean tight fit relation (Choi, 2006), a distinction that is less relevant to the English language. Perhaps these children have yet to home in on the precise spatial relations that are lexically marked in their native language. As a result, if English-reared children have not learned the English preposition "in" that cross-cuts the Korean tight fit relation, they may be more likely to attend to a non-native spatial relation such as tight fit. Future studies may consider examining how English-reared infants' ability to form categories of a non-native event component, such as tight fit, and a native event component, such as manner, relates to their later verb vocabulary.

Finally, another explanation of the current findings is that general intelligence is the underlying third factor fueling both early event categorization and later verb learning. We did not have an additional measure of general cognitive skills and cannot rule out general intelligence as a factor. However, we included children's MCDI scores at Time 1 in the analysis, and they correlate with general cognitive skills (Price et al., 2000). Thus, although it is possible that general intelligence may drive the relationship between event processing and later language, we attempted to control for it by including children's vocabulary knowledge as a variable in the regression model. Furthermore, children's vocabulary skill is often used as a proxy for IQ (Smith, Smith, Taylor, & Hobby, 2005). Future studies should consider measuring children's general cognitive skills (e.g., general categorization skills) independently because it could influence the relationship between infants' early event categorization skills and later relational vocabulary.

In the phonological domain, several longitudinal studies have revealed that individual differences in infants' ability to process and discriminate auditory stimuli at 7.5 months of age predicted subsequent language comprehension and expression scores at 24 months (Benasich & Tallal, 2002). Studies on infants' lexical processing reveal that individual differences in speed and word recognition at 25 months of age correlated with children's expressive language and working memory outcomes at 8 years (Marchman & Fernald, 2008). The current study raised the question of whether an analogous link can be found with events and language. Our results suggest that, as in the phonological domain, individual differences in infants' ability to form categories of event components predict their later knowledge of verbs. The current study, although preliminary, represents significant progress in assessing the factors that may contribute to children's later relational vocabulary.

Although more studies are necessary to establish longitudinal links between event processing and language, infants' early skill in processing event components might eventually be a marker to predict their later relational vocabulary. Research suggests that children with autism have delayed language development, especially with respect to the acquisition of verbs (Parish-Morris, Luyster, Tager-Flusberg, Hirsh-Pasek, & Golinkoff, 2009). Parish-Morris and colleagues (2009) suggested that children on the autism spectrum tend to have a smaller proportion of verbs in their vocabularies on average than typically developing children despite being matched on number of nouns. It is possible that problems with verb learning might not only be linguistic in nature but also have to do with difficulty in finding the precursors of verb meaning in dynamic nonlinguistic events.

Conclusion

Researchers have hypothesized that the ability to acquire verbs has its roots in infants' ability to extract and categorize nonlinguistic event components (Gentner & Boroditsky, 2001; Golinkoff et al., 2002; Golinkoff & Hirsh-Pasek, 2008). However, no previous studies have examined whether there is a relationship between early event processing and later relational vocabulary. The current study addressed this question by demonstrating that individual differences in forming nonlinguistic categories of path and manner at 13 to 15 months of age uniquely predict children's knowledge of verbs at 27 to 33 months. These data suggest that the ability to process conceptual underpinnings of verbs is a prerequisite to the acquisition of relational language in infants.

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